INSTRUCTION MANUAL FOR THE

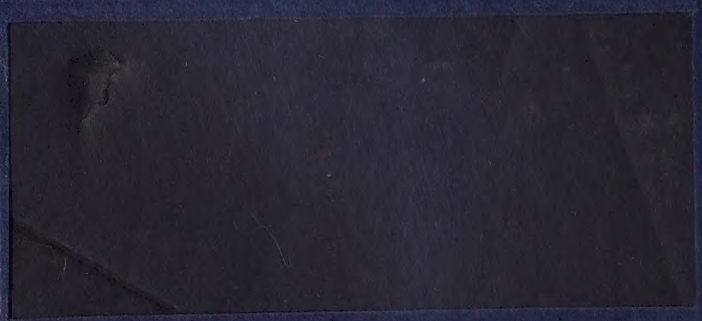
MO-1A, SQUARE WAVE MODULATOR

SER. NO. 61

Weinschel Engineering

KENSINGTON, MARYLAND

WE CO



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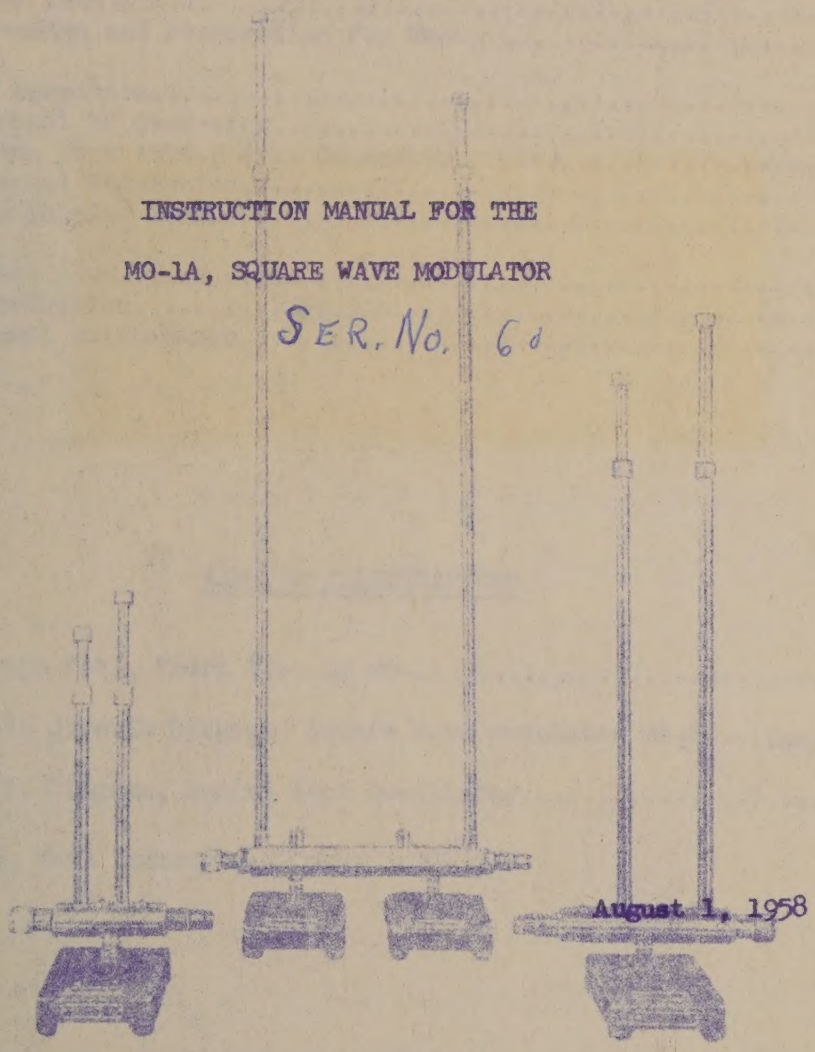

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MO-1A, SQUARE WAVE MODULATOR

SER. No. 60

August 1, 1958

IM #14
15 Pages

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m #79 - (1Page), Test Record

SECTION I

GENERAL INTRODUCTION

1.1 - Scope of Manual

This instruction manual covers the general introduction, theory of operation, operation procedure, and maintenance instructions for the Weinschel Engineering Company's Model MO-1A Square Wave Modulator.

1.2 - Purpose of Equipment

The MO-1A is used to 100% square wave modulate RF signal sources, including klystrons. This type of modulation is used whenever low level RF measurements (voltage or power) have to be made, particularly when only the relative difference of those levels has to be measured. This includes: Attenuation measurements, insertion loss measurements, gain measurements, level establishing and monitoring, etc. At low RF levels the detector output is so small (usually mV or μV) that it is desirable to use AC amplifiers rather than DC amplifiers, because it is a well known fact that the stability problem is much more severe for a low level DC amplifier than for a low level AC amplifier. Therefore, by knowing the detection law of the RF detector the measurement of relative levels can be shifted into the audio range and high measurement accuracies of attenuation and insertion loss may be obtained. The requirement for the square wave as modulation wave shape stem from two facts: First: there should be no frequency modulation present and a changing oscillator plate voltage may result in some frequency modulation. If the transition from zero to full plate voltage is made very rapidly and then held constant, substantially all of the oscillator output is at the frequency corresponding to full plate voltage plus those side bands produced by the amplitude modulation. Second: A generator can always easily be modulated 100% by a square wave, while other wave shapes (like a sine wave) afford careful measurement of the output envelope of the RF generator in setting up the 100% modulation.

The AC amplifiers which are used in conjunction with the RF detectors are usually sharply tuned to the modulation frequency (in most cases, 1000 cps) in order to keep the noise output of the amplifier small and hence extend the measurement range. In order to keep the AC signal stable in amplitude and in phase the modulation frequency has to be very stable. This is achieved in the MO-1A and, therefore, makes the MO-1A an ideal companion instrument to the Bolometer Preamplifier BA-1A, the Audio Substitution Attenuator CF-1, the Attenuation Calibrator BA-5, and the Null Detector ND-1 allowing maximum use to be made of these instruments.

1.3 - Specifications

INTERNAL OSCILLATOR

	Adjustable Oscillator	Tuning Fork Oscillator
Frequency:	1000 cps nominal	1000 cps
Range of Frequency Adjustment:	± 15 cps	None
	± 0.1 cps per hour after 30 minutes warm-up.	
Frequency Stability:	± 0.5 cps per 8 hours. ± 0.05 cps for change of line voltage of ± 10%.	±.01%

OUTPUT

Square Wave:

0--140 volts peak - to - peak coupled thru 2 mfd 1000 volts condenser from cathode follower of source impedance below 200 ohms; recommended load 100,000 ohms minimum.

Sine Wave:

0--25 volts rms; source impedance below 200 ohms; recommended load 100,000 ohms minimum.

Amplitude Stability:

±.02db for change of line voltage by ±10%, independent of amplitude of external synchronization.

Output Connectors:

Panel mounted "BNC" (female) coaxial connectors.

EXTERNAL SYNCHRONIZATION

The internal Wien Bridge Oscillator is disconnected by means of a panel mounted switch. External 10 volts rms are required into a 100,000 ohm load. This synchronizes both Sine Wave and Square Wave output as to frequency.

Frequency Range:

400 to 3000 cycles per second (External Oscillator e.g., H.P. #200 CD).

Connector:

Panel mounted "BNC" (female) coaxial connector.

Controls:

Panel mounted ----- Modulator output, continuous; Synchronization Output, continuous.

Switches:

Panel mounted ----- On-Off-Power; Internal 1000 ± 15 cps, Internal 1000.0 cps, External 400-3000 cps.

Power:

110 VA at 115 volts, 50 - 60 cycles per second.

Dimensions:

Standard relay rack panel 8 3/4 x 19 inches.
Maximum depth behind panel --------13 inches.

Weight:

Net 30 lbs.

1.4 - Description

1.4.1 - Figure 1 is a photograph of the MO-1A showing the arrangement of the front panel controls. Across the bottom of the panel from left to right are: the knobs for fine adjustment of the internal oscillator frequency, the selector control, the input BNC connector for the external synchronizing voltage, the pilot light to indicate when primary power is on, the "on-off" switch, the output control for the sine wave output (with the BNC output connector for the sine wave signal beneath of it), and the output control for the square wave output (with the BNC output connector for the square wave signal beneath of it). The functions of these various controls are described in Section II of this manual.

1.4.2. - The MO-1A consists of two separate audio oscillators, a wave shaping circuit, and two output stages, one for the sine wave and one for the square wave signal. One audio oscillator consists of an RC generator with a high frequency stability whose frequency can be varied ± 15 cps. centered at 1000 cps. This adjustment is necessary in order to set the modulation frequency to the band center frequencies of the different AC amplifiers as mentioned in 1.2. The other audio oscillator is a tuning fork type oscillator tuned to 1000.0 cps, which maintains this frequency within .01%. This oscillator is used when utmost frequency stability is necessary as for instance for high accuracy insertion loss measurements in connection with Weinschel Engineering Co. Model ND-1 as described in Bulletin #45.

By placing the selector switch to "extern. synch." both internal oscillators are turned off and the synchronizing signal may be supplied through the BNC connector marked " input, 10 V RMS". Then the output signals will be coherent to this synchronizing signal, which means they will have the same frequency and a fixed and constant phase relationship. The wave shaping circuit converts the sine wave signal into a square wave signal independent of the synchronizing frequency in the range 400 cps to 3000 cps.

The two output stages (for sine wave and square wave) consist of cathode followers. Because the output controls are in the grid circuits of these cathode followers, the output impedances of these two output stages stay essentially constant under 200 Ω for all output levels. The sine wave output is used merely as a synchronizing signal; the maximum output voltage is about 25 V RMS. The square wave output is used as modulating signal; the maximum output voltage is about 140 V peak to peak which is sufficient to modulate most signal generators and most commercial medium-power klystrons, as e.g., the Sperry series 2K39 and 2K44, inclusive, or the Varian Klystron X 13.

In order to assure good frequency and amplitude stability, an electronically regulated power supply is self-contained in the MO-1A.

1.5 Other uses for the Model MO-1A

Although the main purpose of the MO-1A is to modulate signal sources, it can be used as a medium power, 1000 cps standard source, for applications in the audio range.

1.6 Unpacking and preparation for use.

The instrument is packed in a standard double container with 3" of packing material between the inner and outer case. The only extra items are this Instruction Manual and the line cord. Normal care should be exercised when removing the instrument from the case and removing the packing material. Examine the packing to be sure that there are no loose items before discarding it.

Vacuum tubes are shipped in position and are locked in place with tube clamps. After unpacking examine the instrument for any evidence of damage. If there is any evidence of physical damage to the instrument, notify the shipping company immediately. If there is none proceed with preparations for use.

Make certain that the tubes are properly seated in their sockets and that the fuse is intact. The line cord may now be plugged into a suitable AC outlet. Set the selector switch to "1000±15 cps" and switch the equipment "on". The ruby pilot light should light at once. Allow 60 seconds for the

tubes to warm up and stabilize after which the instrument is ready for use.

SECTION II

THEORY OF OPERATION

Reference to the schematic circuit diagram of the Model MO-1A, Drawing C 114-5 should be made throughout the reading of this section.

2.1 - Internal RC Generator.

The internal RC generator is brought into operation by switching the selector switch to "1000 ±15 cps". It consists of a Wien Bridge and a high gain amplifier. The Wien Bridge contains as frequency determining elements an RC series circuit in the upper branch of the bridge , and a RC parallel circuit in the lower branch. The resistance and capacitance values in both branches are identical, resulting in an impedance at the operating frequency of the upper branch, which is twice the impedance of the lower branch. This is the optimal condition regarding frequency stability.

The amplitude determining element consists of a 3 W lamp, which due to its bias is operated at a point, where the ratio change of resistance/change of dissipated power has a maximum. The feedback amplifier has a voltage gain of approximately 2000 and an output impedance of about 1500 ohms. This together with very stable resistors (precision wire wound resistors) and silver mica capacitors assure an amplitude stability of about .1% and a frequency stability of about .02%. A two-gang variable air capacitor provides the fine adjustment over a ±15 cps range.

2.2 - Tuning fork 1000.0 cps generator

This oscillator will be used when the frequency should be exactly at 1000.0 cps and the frequency stability better than .01%. This is the case if the method is used which is described in Weinschel Engineering Bulletin #45. With this method level changes of .01 dB may be discriminated and attenuations up to 20 dB can be measured with an accuracy of .01 dB. In this method the phase change of the 1000 cps voltage at the output of the RF detector amplifier during one measurement (about 10 minutes) should be smaller than $\Delta\varphi = 3 \times 10^{-3}$.

If we assume an amplifier bandwidth of 30 cps, then within those 30 cps the phase angle of the 1000 cps voltage varies 90° ($\widehat{\varphi} = 1.57$). That means: The frequency change should be smaller than $\pm$ .06 cps during this time. We see how important the frequency stability is in this case. To achieve that a tuning fork Oscillator is built in the MO-1A, which is witched on by turning the selector knob to 1000.0 cps. The tuning fork (Model J, Philamon Lab Inc.) has an effective working Q of approximately 10,000, thus affording excellent frequency stability, with respect to circuit parameter variations. The unit is thoroughly temperature compensated to obtain a frequency accuracy of .01% from -40°C to+85°C. Figure 3 shows the schematic circuit diagram.

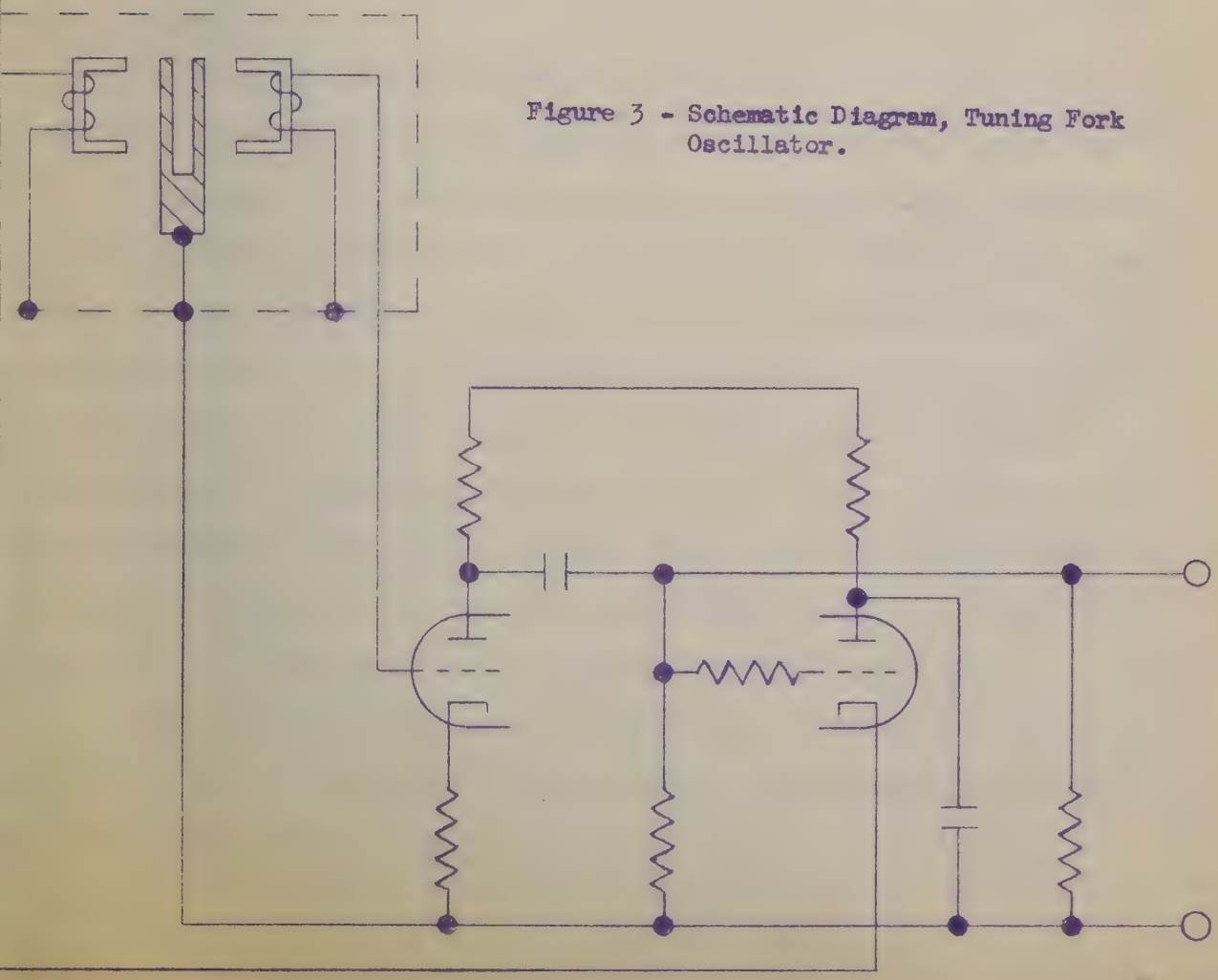


Figure 3 - Schematic Diagram, Tuning Fork Oscillator.

Due to the design of the tuning fork the exact specified frequency is automatically obtained without making provisions of any type of "vernier" frequency control when installing; that means that complete interchangeability between tuning forks is assured.

2.3 External Modulation

With the selector switch turned to "external synch" the plate voltage is removed from V-1, V-3, and V-11 turning off both internal audio oscillators. The modulating frequency can then be applied through the "ext.synch" connector on the front panel.

2.4 Waveshaping Circuit

The output of either the RC generator or the tuning fork oscillator or the external modulating signal is applied to the control grid of V-4 which operates as a straight forward resistance coupled amplifier to drive the cathode coupled clipper V-5.

This cathode coupled clipper, V-5, converts the sinusoidal input to grid #1 to a square wave output at plate #2. Its operation can be understood from the following: In a quiescent condition with no signal input, both triode sections are biased so they are drawing plate current. A positive going signal applied to grid #1 causes the cathodes of both sections to move in a positive direction eventually cutting off the second section thus limiting the positive swing at the output. A negative going signal applied to grid #1 causes the cathodes to move in a negative direction, producing a negative output at plate #2 thus continuing until the first triode section is cut off. Potentiometer P-1, which is chassis mounted, provides an adjustment on the bias of the first triode section so that symmetrical clipping of the input signal occurs.

The capacitor (C-7) between the plate of the first triode section and the grid of the second triode section provides some regenerative feedback producing a fast switching time.

5.Output Stages.

5.1. Sine Wave Output.

The sine wave signal at the plate of V-4 is fed in potentiometer P-3, which is nel mounted above the BNC connector marked " ∿ ". P-3 controls the sine wave gnal which is applied to grid #1 of V-6. Both sections of V-6 are designed as thode followers. The sine wave at the cathode #1 is then brought to the BNC output nnector through a 2 mFd capacitor.

5.2. Square Wave Output.

This stage is similar to the sine wave output stage as described in 2.5.1. The uare wave signal at plate #2 of V-5 is applied to potentiometer P-2 which acts as tput control for the square wave output and is consequently panel mounted above e BNC connector marked "⌐¬⌐". The signal at cathode #2 is brought to this BNC nnector through a 2 mFd capacitor.

The impedances of both cathode follower stages are below 200 ohms.

Section III

Maintenance.

1. Introduction.

The model MO-1A square wave modulator has been designed to require a minimum maintenance. However, should trouble develop and service become necessary, the usual procedure for maintenance of vacuum circuits applies.

2. General Maintenance

3.2.1 Vacuum Tubes.

The checks usually made to determine the condition of vacuum tubes will normally suffice.

3.2.2. Components.

Resistance, capacitance and voltage values are shown in the attached schematic circuit diagram, Drawing # C 114-5. Voltages shown were measured with a 20,000 ohms per Volt meter. The Wien Bridge unit consisting of R-43, R-44, C-26, and C-27, and the tuning fork unit are carefully adjusted at the factory. In case of failure of either one of these units, it should be returned to the factory for repair.

.2.3. Amplitude of Modulating Signal Unstable.

Check with DC meter whether B_+ voltage is correct and stable. If that is the case, proceed:

a) Set selector switch to "ext. sync." and feed a signal of 1000 cps and of 10 V RMS amplitude from a stable source into BNC connector marked " ~ Input". If amplitude of sine wave (signal appearing at BNC connector marked " ~ ") is still unstable, check stage containing V-4. If output is still unstable, change V-6.

If amplitude of sine wave output signal is stable, but amplitude of the square wave modulation signal is unstable, check clipper stage containing V-5.

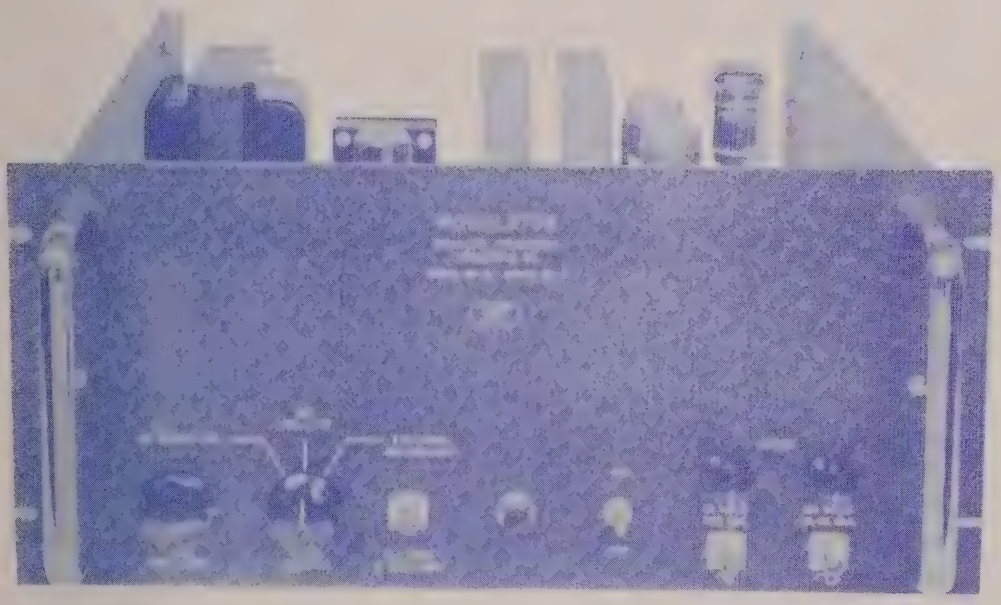
b) Modulation signal amplitude is unstable when selector knob is set to "1000 $\pm$ 15 cps".

Check the wave form of the signal at the RC generator output with an oscilloscope (connect test lead between ground and tie point C-5 - R-9). This signal should be a

sine wave without any visible distortion. Connect test lead to VTVM and check whether the amplitude of the signal at this point is stable and equals 8V $\pm$ 1V RMS. If amplitude is unstable, tighten V-2 (3 W light bulb) in its socket. Lamp should be screwed firmly in the socket. If necessary, replace lamp and adjust R-1 until the amplitude of the above-mentioned signal is equal 8 V RMS (see Note 1 on schematic circuit diagram).

c) Modulation signal amplitutde is unstable when selector knob is set to "1000.0 cps.

Replace V-11 by new tube. If output stays unstable, return tuning fork to factory for inspection.



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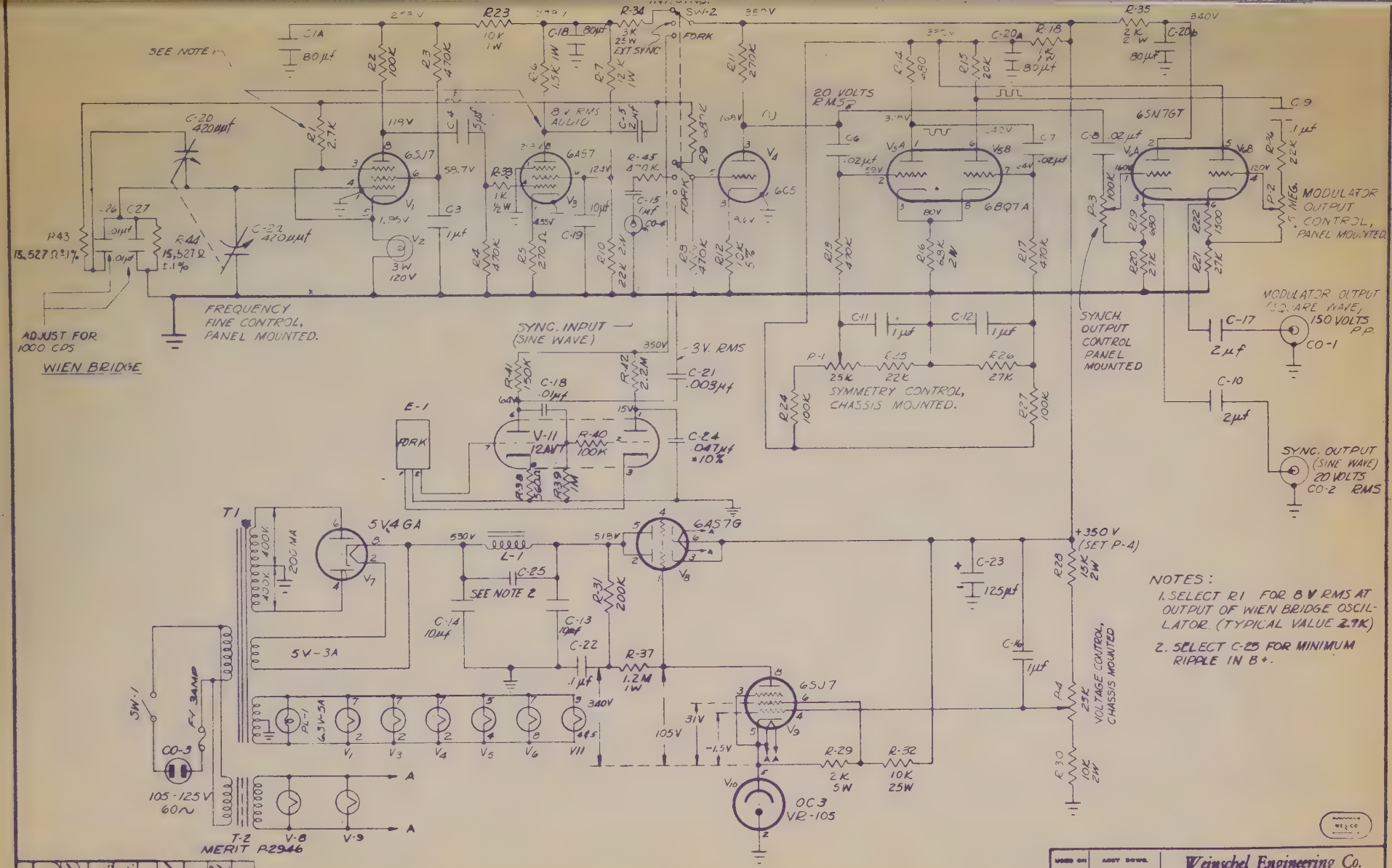
Modulator

Model MO-1A



NOTES:

1. SELECT R1 FOR 8 V RMS AT OUTPUT OF WIEN BRIDGE OSCILLATOR. (TYPICAL VALUE 2.7K)
2. SELECT C-25 FOR MINIMUM RIPPLE IN B+.

REVISIONS			
A	REVISED 9-14-54	4MA	
B	ADDED C-17 9-12-55	DAC	
C	REVISED 5-21-55	DAC	
D	REVISED 10-10-55	JDC	
E	REVISED 5-1-56	MA	
F	REVISED 7-10-56		
G	REVISED PER MCN 11		
H	REVISED PER MCN 13		
J	REVISED PER MCN 13		

Weinschel Engineering Co.
SILVER SPRING, MD.

SCHEMATIC DIAGRAM
SQUARE WAVE MODULATOR-MO-1A

MATERIAL
FINISH
DRAWN 11-23-54 WKJ
SCALE
C 114-5

WEINSCHEL ENGINEERING
KENSINGTON, MARYLAND
TEST RECORD

MODULATOR — MODEL MO-1A

DATE 8-23-59 — SERIAL NUMBER 60

CUSTOMER _____ — JOB NUMBER _____

1. Output Voltage: Line Voltage Set to 115 VAC

Square Wave Output (max.) 151.2 Volts Pk-Pk.

Sine Wave Output (max.) 25.0 Volts rms.

2. Output Amplitude Stability

	Square Wave	Sine Wave (Sync)
Line Voltage = 105 VAC	151.2 Volts	25.0 Volts
Line Voltage = 125 VAC	151.2 Volts	25.0 Volts

3. Frequency Stability

Internal - 1,000 ± 15 cps

Fine Adjustment Range

980 to 1019 cps

After 1/2 Hour 1,000.0 cps

After 1 Hour 1,000.1 cps

Line Voltage = 105 VAC 1,000.0 cps

Line Voltage = 125 VAC 1,000.1 cps

Internal - 1,000.0 cps (Set to 1000.0 cps)

After 15 Minutes 1,000.0 cps

After 1/2 Hour 1,000.0 cps

Line Voltage = 105 VAC 1,000.0 cps

Line Voltage = 125 VAC 1,000.0 cps

Tested by J Gennick Engineer A Vera

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